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UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No. (Z) 98005 P US
Total Pages in this Submission

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

Reticle with Crystal Support Material and Pellicle

and invented by:

Karl-Heinz Schuster & Christian Wagner

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: _____

Which is a:

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: _____

Which is a:

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: _____

Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having **10** pages and including the following:

   a. ☒ Descriptive Title of the Invention
   b. ☒ Cross References to Related Applications *(if applicable)*
   c. ☒ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   d. ☐ Reference to Microfiche Appendix *(if applicable)*
   e. ☒ Background of the Invention
   f. ☒ Brief Summary of the Invention
   g. ☒ Brief Description of the Drawings *(if drawings filed)*
   h. ☒ Detailed Description
   i. ☒ Claim(s) as Classified Below
   j. ☒ Abstract of the Disclosure

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03/02/99 60617 09.5. PTO

Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☒ Formal Number of Sheets 1
   b. ☐ Informal Number of Sheets

4. ☒ Oath or Declaration
   a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☒ With Power of Attorney ☐ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
      Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).

5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Computer Program in Microfiche *(Appendix)*

7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   a. ☐ Paper Copy
   b. ☐ Computer Readable Copy *(identical to computer copy)*
   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers *(cover sheet & document(s))*

9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*

10. ☐ English Translation Document *(if applicable)*

11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations

12. ☐ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ☒ Certificate of Mailing
    ☐ First Class ☒ Express Mail *(Specify Label No.):* EJ662246481US

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Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☒ Additional Enclosures *(please identify below):*

General Authorization to Charge Fees

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	16	- 20 =	0	x $18.00	$0.00
Indep. Claims	4	- 3 =	1	x $78.00	$78.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$760.00
OTHER FEE *(specify purpose)* _____					$0.00
				TOTAL FILING FEE	$838.00

☒ A check in the amount of **$838.00** to cover the filing fee is enclosed.

☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **11-0665** as described below. A duplicate copy of this sheet is enclosed.

- ☐ Charge the amount of _____ as filing fee.
- ☒ Credit any overpayment.
- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

M. Robert Kestenbaum

Signature

Dated: **March 2, 1999**

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cc:

Reticle With Crystal Support Material and Pellicle

Cross-References to Related Applications

Not applicable.

Statement Regarding Federally Sponsored Research or Development

Not applicable.

Background of the Invention

Field of the Invention

The invention relates to a reticle whose transparent support material consists of an optically uniaxial crystal.

Discussion of Relevant Art

A reticle for 100-200 nm lithography whose substrate is to consist of MgF_2, or equally well of CaF_2 or diverse other fluorides, is described in German Patent DE 34 17 888 A (British Patent document 21 39 781). Manifestly only their transparency in the given wavelength region is considered as the selection criterion. Nothing is said concerning the crystal structure, birefringence, thermal expansion, and polarization.

In the Technical Publication TP 58401, 157 nm lithography with transparent optical elements, of MgF_2 among others, is described without being specified in more detail.

MgF_2 is a typical optically uniaxial crystal.

A radially polarization-rotating optical arrangement, and a microlithography projection illumination equipment therewith, is described in German Patent DE 195 35 392 A.

Lithography with the excimer laser wavelength of 157 nm can no longer fall back on the proven quartz glass as reticle support material, since quartz glass is opaque in the given spectral region. Isotropic CaF_2 has a drastically higher linear thermal expansion coefficient of $18.9 \cdot 10^{-6}/°K$, as against $0.5 \cdot 10^{-6}/°K$ for quartz glass.

The already proposed MgF_2 (magnesium fluoride) has a markedly smaller thermal expansion. Based on the crystal structure, however, not only is this crystal optically uniaxially birefringent, but also the thermal expansion is anisotropic.

Pellicles are thin diaphragms for the protection of the mask structure on the reticle. Besides organic foils, SiO_2 pellicles are also known. Japanese Laid-Open Patent Publication JP-A-4-081756 describes a pellicle in which a fluoropolymer is coated on both sides with CaF_2.

Summary of the Invention

The invention has as its object to provide a reticle, which is suitable for wavelengths in the 100-200 nm region and which is improved as regards its thermal and optical properties. The same holds for a pellicle

according to the invention.

The object is attained by a reticle according to the invention with support material of transparent, optically uniaxial crystal, in which the principal axis (A) of the crystal is substantially perpendicular to the surface of the reticle. Advantageously, the support material is MgF_2. According to the invention, the axial direction of the crystalline support is oriented such that the thermal expansion within the reticle surface is homogeneous. Ideally, this is obtained with an exactly perpendicular orientation of the crystal axis. However, deviations arising from manufacturing technology, for example, can be tolerated to the extent that the resulting increasingly unequal thermal expansion can be tolerated. The tolerance of 5° represents a measure above which the embodiment would be little appropriate.

MgF_2 is the preferred optically uniaxial crystal.

The disturbance of the microlithographic imaging by thermal expansion can be additionally reduced by means of a cooling device according to an advantageous feature of the invention.

An optimization of the optical properties also results according to an advantageous feature of the invention from bonding the thus constituted reticle into an illumination equipment that provides radially polarized light. The refraction at the crystal is thereby no longer dependent on

direction. For the tolerance against deviations of the optical axis from the crystal axis, the above-mentioned correspondingly holds, and hence it is advantageous to include in such illumination equipment the features described above.

An illuminating device is thus provided with a reticle that is transparent at light wavelengths of 100-200 nm, in which anisotropies of thermal expansion and of refraction play no part, and the absolute amount of the thermal expansion is halved in contrast to CaF_2 ($9.4 \cdot 10^{-6}/°K$) as the most prevalent comparison material.

A further advantageous embodiment of the reticle according to the invention is provided by suitable cooling.

The constitution of a pellicle according to the invention consists of a fluoride crystal, preferably CaF_2, or BaF_2 or MgF_2.

Brief Description of the Drawing

The invention will be described in more detail with reference to the example shown in the accompanying drawing, in which

Fig. 1 shows, schematically, a projection illumination equipment of the kind according to the invention.

Detailed Description of Preferred Embodiments

A DUV excimer laser 21 with e.g. 157 nm wavelength forms, with an

optics 2, an illumination system which is supplemented with a radial polarizer 22 according to German Patent document DE 195 35 392 A. A light pencil 20, with radial polarization as indicated by the vectors P_L and P_R and the optical axis A, is thus produced.

The light pencil 20 passes through a reticle 1 with non-transmitting structures 11, e.g. of chromium, on the transparent support 10. This is formed of MgF_2 here, with an orientation of the main axis in the direction of the optical axis A. The structures 11 are then imaged through the projection objective 3, e.g., a mirror objective, onto the wafer 4, which is positioned on a carrier device 41. The structures 11 are arranged on the side of the support 10 remote from the projection objective 3, since the support material 10 is then not arranged in the imaging path proper. The reticle 1 is fastened in a positioning device 12.

The reticle 1 is arranged between two plane parallel cover plates (pellicles) 13, 14 of material of suitable transparency, e.g., CaF_2, BaF_2, or of MgF_2 having the same orientation, which are connected to a duct system 51, 52 and a cooling system 5. The reticle 1 can thereby be flushed with a fluid 50, preferably a gas, and indeed most suitably helium. There is thus made possible an effective temperature equalization between regions of the reticle 1 that are differently endowed with structure 11, or are irradiated

with different intensity by the light pencil 20, and also an overall cooling and temperature stabilization. Preferably a countercurrent cooling of the front and back side of the reticle 1 is used, as in the example.

The pellicles 13, 14 of fluoride crystal are also advantageous in combination with reticles of other material, with or without fluid cooling.

Production preferably proceeds from 111-oriented crystal plates, which are polished conventionally and/or with an ion beam.

The reticle according to the invention, the pellicle and the system are also suitable for a contact illumination equipment.

The reticle according to the invention can also be used without the radial polarization of the illumination light pencil. If circular polarization of the light is introduced, all the effects of the birefringence are rotationally symmetrical with respect to the optical axis A, and are therefore tolerable in many ways.

We claim:

1. A reticle with support material (10) of transparent, optically uniaxial crystal, in which the principal axis (A) of said crystal is substantially perpendicular to the surface of said reticle (1).

2. A reticle based on MgF_2 as support material (10), in which principal axis (A) of said MgF_2 is oriented substantially perpendicular to the surface of said reticle (1).

3. The reticle according to claim 1, in which said principal axis is oriented perpendicular ± 5° to the surface of said reticle (1).

4. The reticle according to claim 1, further comprising a cooling device (5, 13, 14, 50, 51, 52).

5. The reticle according to claim 4, in which said cooling device (5, 13, 14, 50, 51, 52) has a flowing fluid (50).

6. The reticle according to claim 2, in which said principal axis is oriented perpendicular ± 5° to the surface of said reticle (1).

7. The reticle according to claim 2, further comprising a cooling device (5, 13, 14, 50, 51, 52).

8. An illumination equipment for microlithography comprising:
an illumination system (2), and
a reticle (1) with magnesium fluoride as support material (10),

in which said illumination system (2) provides radially polarized light (20, P_L, P_R), and said magnesium fluoride is oriented with its crystal principal axis substantially in the direction of the optical axis (A) at said reticle (1).

9. An illumination equipment for microlithography comprising:

an illumination system (2),

a reticle (1) with support material (10) of transparent optically uniaxial crystal,

in which said illumination system (2) provides radially polarized light (20, P_L, P_R), and said support material (10) is oriented with its principal axis substantially in the direction of the optical axis (A) at said reticle (1).

10. The illumination equipment according to claim 6 or 7 with a reticle according to claim 5.

11. The reticle according to claim 6 or 7, further comprising a fluid cooling system.

12. The reticle according to claim 9, further comprising at least one flat plate (13, 14) arranged parallel at said reticle (1), in which a fluid (50) flows between said reticle (1) and said flat plate (13, 14).

13. The reticle according to claim 10, in which said flat plate (13, 14)

comprises crystal.

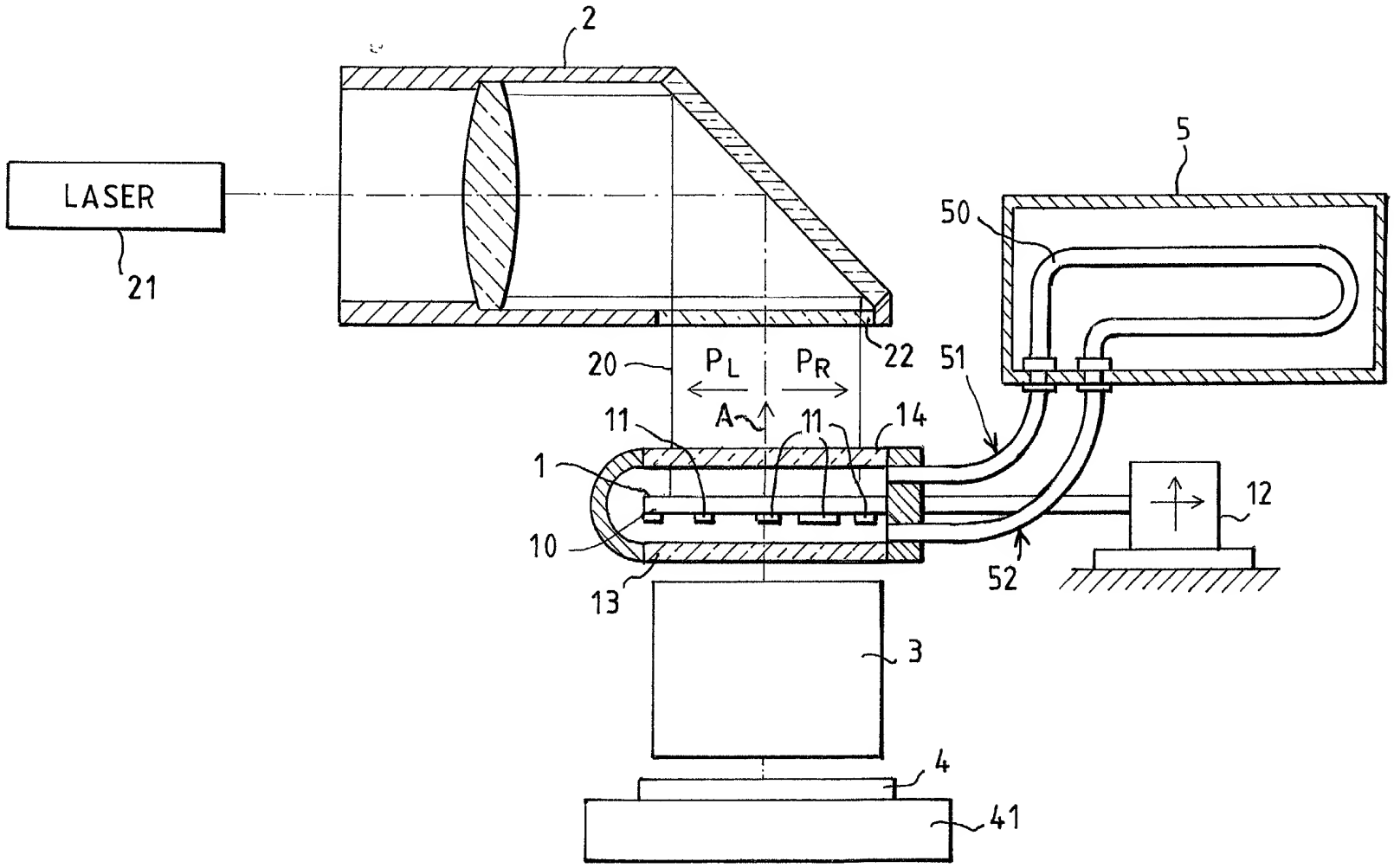
14. The reticle according to claim 11, in which said crystal comprises CaF_2 or MgF_2.

15. A pellicle (13, 14) of fluoride crystal.

16. The pellicle (13, 14) according to claim 13 comprising a fluoride selected from the group consisting of CaF_2, BaF_2, or MgF_2.

Abstract of the Disclosure

An illumination equipment for microlithography has an illumination system, and a reticle with magnesium fluoride as the support material. The illumination system provides radially polarized light, and the magnesium fluoride is oriented with its principal axis about in the direction of the optical axis (A) at the reticle. In addition, a suitable cooling system is described.



Docket No.
(Z) 98005 P US

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Reticle with Crystal Support Material and Pellicle

the specification of which

☐ (check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
198 08 461.7	**Germany**	**02/03/1998**	☐
(Number)	(Country)	(Day/Month/Year Filed)	
			☐
(Number)	(Country)	(Day/Month/Year Filed)	
			☐
(Number)	(Country)	(Day/Month/Year Filed)	

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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Sole or first inventor's signature
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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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